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Small arms propellant manufacturer Hodgdon claims that rifle powders in its Extreme line have small velocity variations with both temperature changes and lot number. This paper reports on the variations in average velocity for six different lots of Hodgdon Extreme H4831 tested in .25-06 and .300 Winchester Magnum loads. Compared to the lot with the slowest average velocity, the other five lots of powder had higher average velocities ranging from 11.9 ft/s faster up to 111.9 ft/s faster in the .25-06 and from 13.6 ft/s faster to 111.1 ft/s in the .300 Win Mag. The mean velocity differences between lots are highly correlated between the two cartridges with a correlation coefficient of 0.96. This high correlation supports the idea that the experimental results reported here depend much more strongly on differences in the lots of powder rather than other details of the experiment such as the choice of primers, brass, bullets, and specifications of the rifle bore. The lot to lot variations in velocity seem higher than one might expect from Hodgdon's marketing claims.

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# Powder Lot Variations: A Case Study with H4831 – Hodgdon Extreme

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## Abstract
Small arms propellant manufacturer Hodgdon claims that rifle powders in its Extreme line have small velocity variations with both temperature changes and lot number. This paper reports on the variations in average velocity for six different lots of Hodgdon Extreme H4831 tested in .25-06 and .300 Winchester Magnum loads. Compared to the lot with the slowest average velocity, the other five lots of powder had higher average velocities ranging from 11.9 ft/s faster up to 111.9 ft/s faster in the .25-06 and from 13.6 ft/s faster to 111.1 ft/s in the .300 Win Mag. The mean velocity differences between lots are highly correlated between the two cartridges with a correlation coefficient of 0.96. This high correlation supports the idea that the experimental results reported here depend much more strongly on differences in the lots of powder rather than other details of the experiment such as the choice of primers, brass, bullets, and specifications of the rifle bore. The lot to lot variations in velocity seem higher than one might expect from Hodgdon's marketing claims.

**Key Words:** bullet velocity internal ballistics, variation, powder lot, nitrocellulose[1]

## Introduction
The Hodgdon Extreme line of powders has long been a top choice of long range match shooters and long range hunters, in large part due to its marketing claims regarding smaller temperature variations than other brands and small lot to lot performance variations. (Hodgdon 2012a)

*Hodgdon goes through painstaking measures to ensure that all powder is consistent from lot to lot. And while the casual user may never notice, you certainly will. No matter when you purchase Hodgdon powder, you can feel confident that the performance you receive from one lot will match that of another.*

The reloading benches at BTG Research pay homage to the Hodgdon Extreme line of powders, with exactly one canister of a powder made by another company (Alliant Blue Dot). We decided years ago to stick with the Hodgdon Extreme line of powders due to their advertised claims of small velocity variations with temperature and lot number. However, over the years we noticed more significant variations than one might expect from Hodgdon marketing claims.

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One powder from the Hodgdon Extreme line (H1000) is known to be in current use in a military cartridge (the .300 Win Mag) and the detailed specifications require only one lot of powder be used in any lot of ammunition. (Endris, 2009) The specifications also require a maximal velocity variation of 75 ft/s across the required temperature range (-20 F to 165 F). Since sniper and counter sniper engagement distances beyond 1000 yards have become more common in the Afghanistan conflict, several NATO nations have moved to cartridges with higher powder capacities such as the .300 Win Mag and the .338 Lapua Magnum. (Endris, 2009; Webb, 2007) Other high-capacity cartridges such as the .338 Norma Magnum have been suggested as a longer range machine gun cartridge (Steimke, 2012), and lighter recoiling cartridges similar to the 6.5x284 Norma will probably be considered by units with counter snipers of smaller stature for applications beyond 1000 yards.

Potential longer range cartridges are all considered to be “overbore” in that they employ a larger volume of slower burning powders than earlier generations of cartridges including the 7.62 mm NATO, the 5.56 mm NATO, and the 7.62x39 mm. Long range applications also require smaller variations in muzzle velocity from shot to shot, with variations in ambient temperature, with variations in barrel temperature, and with variations in the lot number of components. Due to their marketing claims, their reputation among long range target shooters, and the selection of a Hodgdon Extreme powder in the .300 Win Mag sniper load (Endris, 2009), Hodgdon Extreme powders with slower burning rates are natural choices to consider in long range applications. These slower burning powders in the extreme line include H4350, H4831, H1000, and Retumbo.

Unsatisfied with current temperature testing methods, the authors have talked quite a bit about how to carry out a convincing experiment to test velocity variations over temperature but decided to start with an experiment testing velocity variations over different lots of powders, because the experiment is more straightforward and has fewer potential confounding factors. For example, when testing effects of temperature variations, the temperature differences might affect neck tension, primer performance or barrel friction, any of which could create velocity variations independently of the powder dependence on temperature. In contrast, in an experiment testing velocity variations with lot number, other factors can be held constant.

## Method

Powder was acquired from six different lots of H4831, designated A-F, and allowed to acclimate in the same storage area for over a year. All six lots were kept in their original canisters and opened briefly from time to time. The temperature at which the powder was stored varied seasonally from 55 F in the winter to nearly 70 F in the summer. The relative humidity varied from 25% to 50%. Ten rounds were loaded with each of the six powders in 25-06 and .300 Win Mag (60 rounds total in each cartridge). The .25-06 rounds were loaded in R-P brass using a Fed 210M primer, 52 grains of powder, and a 115 grain Berger VLD bullet. The .300 Win Mag loads were loaded in Nosler brass using a Fed 210M primer,[2] a 155 grain AMAX bullet, and 79 grains of powder. Power was carefully weighed by hand to a precision of

2 Over the years, we've noticed better consistency in velocities using Fed210M rather than Fed215M to ignite cylindrical powders in cases up to .300 Win Mag, though this observation is anecdotal and not the result of carefully controlled experiments. Also see Courtney and Courtney (2011).

0.02 grains on a digital scale. Brass preparation method included cleaning in stainless tumbling media, reaming the primer pockets, and chamfering the flash hole and case neck with appropriate tools. Cleaning brass in stainless tumbling media is important to consistency. For example, we have noticed an increase in case capacity averaging close to 1 grain of water after cleaning previously fired .300 Win Mag cases.[3] In addition to the ten rounds with each lot of powder, ten warm-up rounds were prepared with one of the powder lots.

The two test rifles were a factory Savage 110 BA in .300 Win Mag and a Remington 700 Sendero in .25-06. Before the experiment, the rifle barrels were cleaned thoroughly with our standard laboratory procedure. Velocities were measured with a CED Millenium chronograph with LED sky screens. Previous work has shown that the accuracy of these chronographs is about 0.3%. Four of the warm-up shots were fired to condition the bore and warm the barrel. Then one shot was fired from each lot of powder in sequence to interleave the lots of powder as the sixty shots were fired. Data was recorded in a field notebook for later entry into a spreadsheet for analysis. Interleaving the shots prevented confounding effects from barrel friction and barrel temperature changing in time. The shots were not carefully timed, but a regular cadence was maintained. If a break was needed for some reason, between two and four additional warm-up shots were fired, depending on the length of the break, so the experiment would not resume with a cold bore. In the actual firing sequences, breaks were only due to the occasional cease fire and only lasted a few minutes.

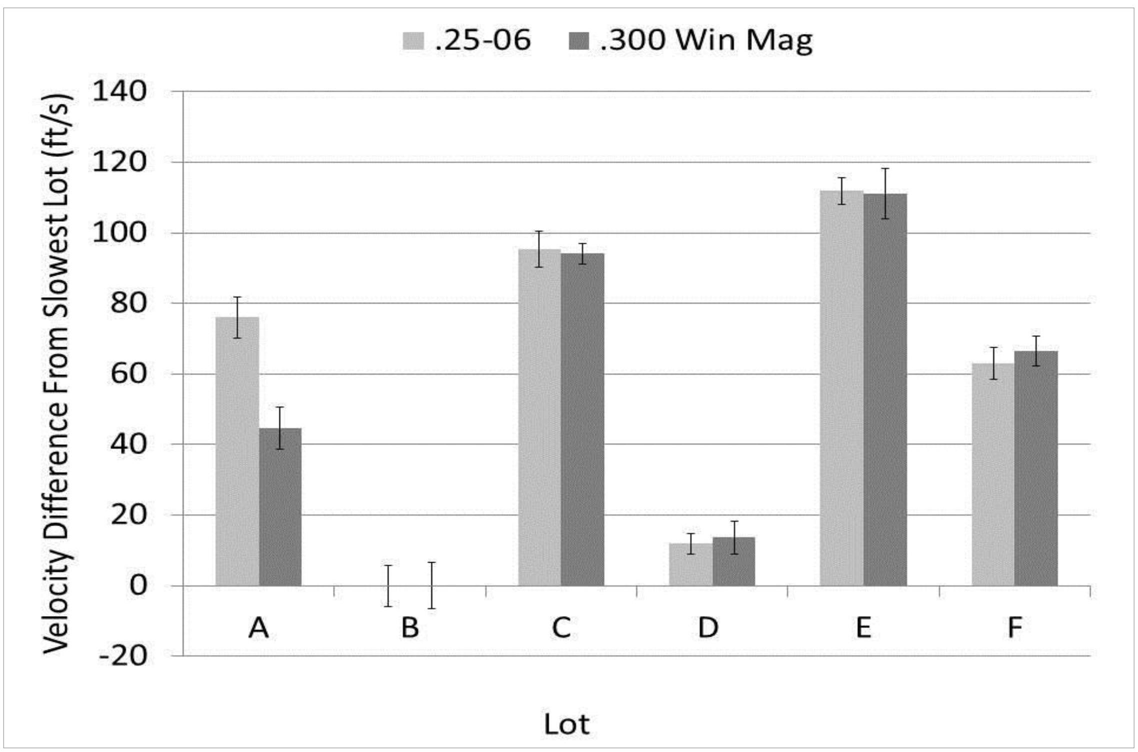


*Figure 1: Average velocity variation for the six lots of H4831 compared with the slowest lot of powder which turned out to be lot B in both the .25-06 and the .300 Win Mag.*

3 This observation of increased case capacity was before and after cleaning fired cases, without any additional firing between determining capacity before and after cleaning.

After the data was entered into a spreadsheet, the average (mean) velocities and uncertainties in the means were computed for each of the six lots of powder. To present the spread of velocities clearly, velocity differences were computed relative to the lot which gave the slowest average velocity. The uncertainties in the mean were computed as the standard error of the mean using the spreadsheet standard deviation function divided by the square root of the number of shots fired for each lot.

**Results**

Variations in average velocity (and uncertainties) for both the .300 Win Mag and the .25-06 loads with the six different lots of or powder are shown in Figure 1. Lot B had the lowest average velocity of 3122.5 ft/s in the .300 Win Mag and 2832.9 ft/s in the .25-06. Lot D had the smallest velocity variation compared with lot B at 11.9 ft/s in the .25-06 and 13.6 ft/s in the .300 Win Mag. Lot E had the largest increase in velocity compared with lot B with an increase of 111.9 ft/s in the .25-06 and 111.1 ft/s in the .300 Win Mag. Except for lot A, the increases in velocity are surprisingly similar for the a given lot in both cartridges. In fact, the velocity variations with lot number of the two different cartridges have a correlation coefficient of 0.96 (including lot A). This high level of correlation demonstrates that the velocity variations depend much more strongly on the lot number than on other factors such as bore, brass, primer, or bullet. Table 1 shows the actual mean velocity of 10 shots for each combination of load and powder lot.

| Lot | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| .300 Win Mag | 2909 | 2833 | 2928 | 2845 | 2945 | 2896 |
| .25-06 | 3167 | 3123 | 3217 | 3136 | 3234 | 3189 |

*Table 1: Average velocities (ft/s) for each lot of powder in each cartridge.*

**Discussion**

The high level of correlation between results for the two cartridges suggests that testing lot to lot variations in powder performance in one cartridge and rifle has a good chance of accurately predicting lot to lot variations in other cartridges and rifles. Velocity variations over 100 ft/s have significant implications for both accuracy and pressure when switching to a new lot of powder. In testing the .25-06 loads, the spotter was able to call low velocities before looking at the chronograph by noting a low point of impact at 500 m. These observations agree with the prediction of the JBM ballistic calculator of the point of impact being 6.2 inches low at 500 m with the lower velocity. Velocity variations this large will also change barrel dwell time and resulting harmonics.

To consider the likely pressure variations, consider that QuickLoad V3.6 predicts a muzzle velocity of 3174 ft/s and a peak pressure of 54371 psi for 79 grains of H4831 using the 155 grain AMAX in the .300 Win Mag. This is very close to the 3177.5 ft/s velocity that results from averaging the measurements over all six lots of powder. However, compensating for possible lot to lot velocity variations requires a range of powder charges spanning from 77.5 to 80.5 grains of powder and a range of pressures from 51063 psi to 57910 psi. It is possible that a load showing no signs of pressure with one lot of powder might not be safe with another lot of powder. At their web site, Hodgdon recommends working up new loads when the lot number of any component is changed, and it is evident that this includes a new lot of Hodgdon

Extreme powder (Hodgdon, 2012b):

*For all brands of powders use only the components shown. If the reloader makes any changes in components or gets new lot numbers, he should begin again with the starting loads and work up to maximum cautiously.*

The data shown here suggest the likely need for ammunition manufacturers to conduct performance testing when receiving new lots of powder from Hodgdon, and for end users to conduct performance testing when receiving new lots of ammunition from manufacturers. Hodgdon's marketing claims should not be depended upon to assure lot to lot consistency without due diligence from end users. Given that the tests described here failed to verify Hodgdon's claims regarding lot to lot variations of their Extreme line of powder, it is also likely that greater diligence is needed regarding claims of temperature stability.

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